450043

FLOOD INSURANCE STUDY

TOWN OF RAVENEL, SOUTH CAROLINA
CHARLESTON COUNTY

best copy available

OCTOBER 1, 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 450043

FEMA 1.209

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
1.1	Purpose of Study	1
1.2	Authority and Acknowledgments	1
1.3	Coordination	1
2.0	AREA STUDIED	2
2.1	Scope of Study	2
2.2	Community Description	2
2.3	Principal Flood Problems	4
2.4	Flood Protection Measures	4
3.0	ENGINEERING METHODS	4
3.1	Hydrologic Analyses	4
3.2	Hydraulic Analyses	6
4.0	FLOOD PLAIN MANAGEMENT APPLICATIONS	7
4.1	Flood Boundaries	7
4.2	Floodways	7
5.0	INSURANCE APPLICATION	10
5.1	Reach Determinations	11
5.2	Flood Hazard Factors	11
5.3	Flood Insurance Zones	11
5.4	Flood Insurance Rate Map Description	12

TABLE OF CONTENTS - continued

		Page
6.0	OTHER STUDIES	12
7.0	LOCATION OF DATA	12
8.0	BIBLIOGRAPHY AND REFERENCES	14-15

FIGURES

Figure 1 -	Vicinity Map	3
Figure 2 -	Floodway Schematic	10

TABLES

Table 1 -	Summary of Discharges	5
Table 2 -	Summary of Elevations	6
Table 3 -	Floodway Data	9
Table 4 -	Flood Insurance Zone Data	13

EXHIBITS

Exhibit 1 - Flood Profiles
Middle Branch — Panels 01P-02P

Exhibit 2 - Flood Boundary and Floodway Map Index

Exhibit 3 - Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the Town of Ravenel, Charleston County, South Carolina, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert the Town of Ravenel to the regular program of flood insurance by the Federal Insurance Administration (FIA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally-supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 24 CFR, 1910.1 (d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Law Engineering Testing Company for the Federal Insurance Administration, under Contract No. H-4753. This study was completed in October 1979.

1.3 Coordination

Streams requiring detailed study were identified at a meeting attended by representatives of the study contractor, the FIA, and representatives of Ravenel in Goose Creek, South Carolina on April 25, 1978. Results of the hydrologic analyses were coordinated with the U.S. Army Corps of Engineers (COE), the U.S. Geological Survey (USGS), and local town officials.

On April 1, 1980, the results of the study were reviewed at the final meeting attended by representatives of the study contractor, FIA, and community officials. The study was acceptable to the community.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the Town of Ravenel. The area of study is shown on the Vicinity Map (Figure 1).

Approximate methods of analyses were used to study those areas having a low development potential or a minimal flood hazard. The areas studied by detailed methods were selected with priority given to all known flood hazard areas, and areas of projected development.

The limits of detailed and approximate studies in Ravenel were determined by FIA with community and study contractor consultation at the meeting in April 1978, in Goose Creek, South Carolina.

Floods caused by overflow of Middle Branch from U.S. Highway 17 to New Road were studied in detail. The flood boundary for Mellichamp Branch, the Wallace River, and a tributary of Wallace River was delineated using approximate methods.

2.2 Community Description

The Town of Ravenel is located in the coastal area of South Carolina in the western part of Charleston County. Ravenel is approximately 15 miles west of the City of Charleston, South Carolina, along U.S. Highway 17. As estimated from the 1970 census of population data, the population of Ravenel is 931 (Reference 1).

Middle Branch flows through Ravenel and drains approximately 40 percent of the land area. Middle Branch discharges into the Wallace River. The stream has a length of approximately 6.3 miles within Ravenel and drains about 7.2 square miles.

The portion of the town drained by Middle Branch is largely agricultural with some single family residential areas. The development within the flood plains studied consists of single family residential. The town is served by U.S. Highway 17, S.C. Highway 165, and the Seaboard Coast Line Railroad.

The Town of Ravenel is in the coastal plains area of South Carolina with most of the area being 20 feet National Geodetic Vertical Datum of 1929 (NGVD). The area is very flat with large marsh area and several tidal streams.

The climate in the coastal South Carolina area is temperate and rainy. Summer and winter average temperatures range from 80.4 degrees F to 46.5 degrees F, respectively. Annual average precipitation for the area is 48.6 inches. The average precipitation is heaviest during the summer months and there are no months with extremely low precipitation.

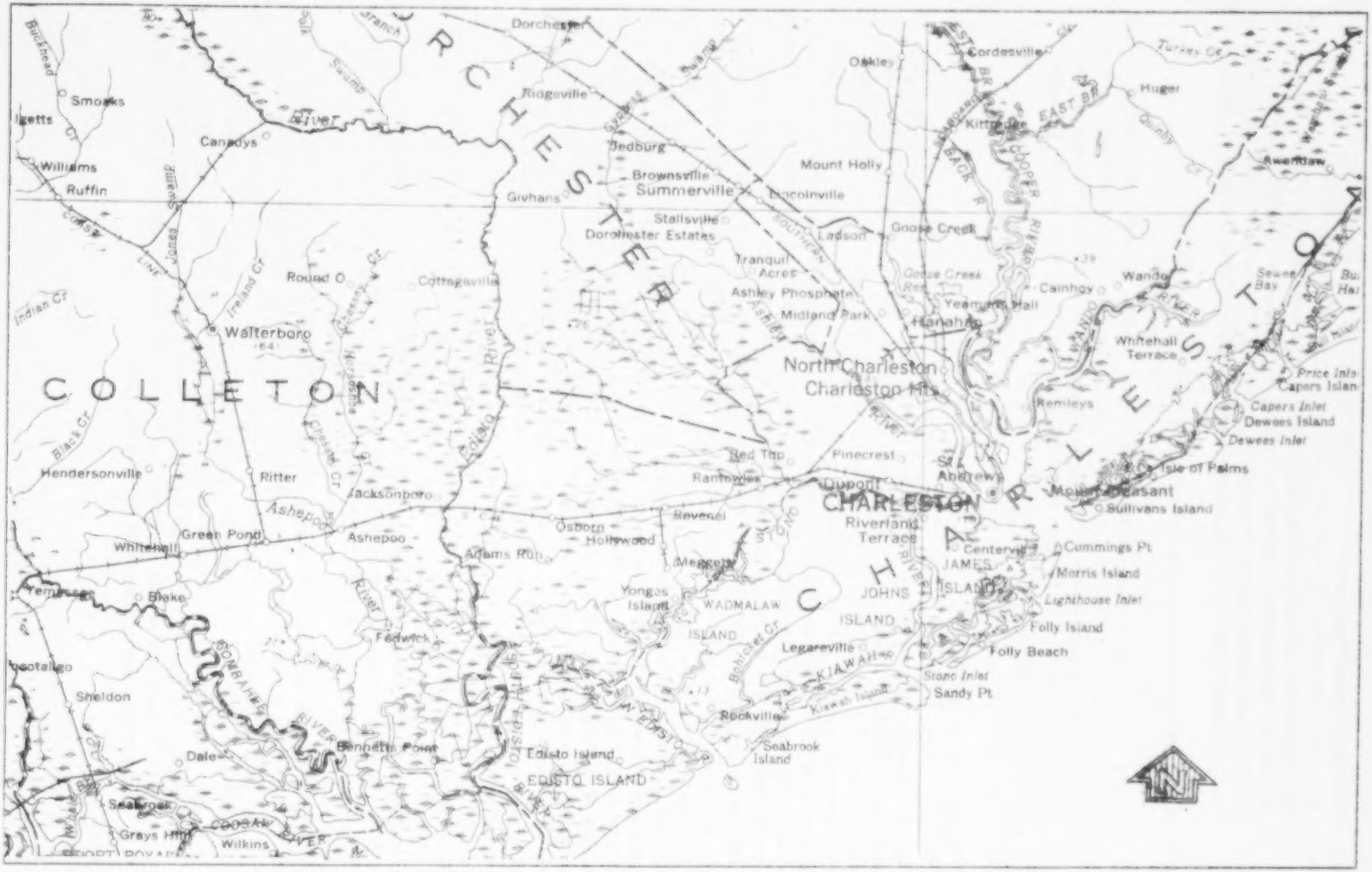


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF RAVENEL, SC
(CHARLESTON CO.)

APPROXIMATE SCALE
0 5 0 5 10 34 MILES

VICINITY MAP

2.3 Principal Flood Problems

Past history of flooding along Middle Branch within the Town of Ravenel indicates that flooding may occur during any season of the year. Prior flooding has caused water to overtop S.C. Highway 165 on several occasions. Also, shallow flooding of depressed areas is prevalent in Ravenel (Reference 2).

2.4 Flood Protection Measures

There are no flood protection structures on Middle Branch. Presently, Ravenel has no ordinances or zoning regulations governing development in the flood plains. In recent history the only flood protection measures undertaken on Middle Branch involved the placing of new culverts under existing roadways.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, and 500-year period (recurrence intervals), have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one percent chance of annual occurrence) in any 50 year period is about 40 percent (four in 10), and for any 90 year period, the risk increases to about 60 percent (six in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail in the community.

For Middle Branch in Ravenel, the natural discharges were calculated using the USGS administrative report "Estimating the Magnitude of Peak Discharges for Selected Flood Frequencies on Small Streams in South Carolina" (Reference 3). This report is a regional approach based on multiple regression analysis. This analysis related peak discharge to drainage area, slope, length, precipitation intensity and soils index. Drainage area explained 85 to 90 percent of the variation of the dependent variable, while the other independent variables were not significant.

The Sauer Method was used to adjust the natural flows for the effects of urbanization (Reference 4). This method relates the urbanized peak discharge for any return interval to the percentage of area served by storm sewers, percentage of impervious area, the rainfall intensity ratio, and the natural peak discharge. The percent impervious area for any given land use was obtained from Soil Conservation Service, Technical Release No. 55 (Reference 5). For this study the percent impervious area was assumed to equal the percent of the area served by storm sewer.

The peak discharge-drainage area relationships for the selected recurrence intervals are presented in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
MIDDLE BRANCH					
Downstream corporate limits	7.2	641	1,138	1,498	2,447
Miley Hill Road	4.2	466	832	1,108	1,826
SC Highway 165	2.8	367	658	883	1,466
New Road	1.7	274	492	668	1,118

The lower portions of Middle Branch are influenced by the Atlantic Ocean tides. Therefore, storm induced tidal surges were also considered in the detailed study. Hydrologic analyses were carried out to establish the peak tidal frequency-elevation relationships for floods of the selected recurrence intervals for Middle Branch.

The peak tidal elevations were determined using the National Oceanic and Atmospheric Administration Technical Report "Storm Tide Frequencies on the South Carolina Coast" (Reference 6). In this report,peak storm tide elevations with annual frequencies from 0.10 to 0.002 were calculated for the South Carolina coast. These elevations were obtained by applying the National Weather Service hydrodynamic storm surge model to a full set of climatologically representative hurricanes.

These elevations were then adjusted to allow for decay of the storm surge inland. The 100-year flood elevation at U.S. Highway 17 in Ravenel was obtained from the Charleston County Flood Hazard Insurance Study (Reference 7). This elevation was derived using methods described in the Charleston County Flood Insurance Study (Reference 8). The proportion by which the 100-year storm tidal elevation was attenuated from the open coast to Middle Branch at U.S. Highway 17 was then applied to the 10-, 50-, and 500-year open coast storm tidal elevations. A summary of the peak storm tides for Middle Branch at U.S. Highway 17 is shown in Table 2, "Summary of Elevations."

TABLE 2 - SUMMARY OF ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION ABOVE NGVD (feet) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
ATLANTIC OCEAN				
At North Edisto River	6.4	10.2	12.9	16.6
Middle Branch at U.S. Highway 17	4.0	6.3	8.0	10.3
Tributary of Wallace River at U.S. Highway 17	*	*	7.0**	*

*Not available
**Reference 8

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail in the Town of Ravenel were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of the flood sources.

Several cross sections for the backwater analyses of Middle Branch were field surveyed by Law Engineering Testing Company. Additional cross sections were obtained by using the field surveyed invert elevations, and channel geometry in conjunction with USGS Quadrangles (Reference 9). All bridges and culverts were field checked to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). Also, these selected cross section locations are shown on the Flood Boundary and Floodway Map (Exhibit 4), for stream segments for which a floodway was computed (Section 4.2).

Channel roughness factors (Manning's "n"), used in the hydraulic computations, were chosen by engineering judgement and based on field observations of the streams and flood plain areas. The roughness value for the main channel of Middle Branch ranged from 0.04 to 0.05 with flood plain roughness values ranging from 0.07 to 0.12 for all floods.

Water-surface elevations of floods of the selected recurrence intervals were computed through use of the COE HEC-2 step-backwater computer program (Reference 10).

Flood profiles were drawn using both the elevations obtained from the backwater computations and storm tide elevations for the selected recurrence intervals. The backwater computations were obtained for the entire flooding source by neglecting the tidal influences. The tidal elevations were then superimposed on the backwater elevations, showing only the

higher of the two elevations. Starting water-surface elevations for the backwater computation for Middle Branch were calculated using the slope-area method. All elevations are referenced from the National Geodetic Vertical Datum of 1929 (NGVD), formerly referred to as Sea Level Datum of 1929; elevation reference marks used in this study are shown and described on the maps.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and the 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 and 1:62,500 with contour intervals of 5 and 20 feet, respectively (Reference 8). In cases where the 100- and the 500-year flood boundaries are close together, only the 100-year boundary has been shown.

For the stream delineated as approximate, the boundary of the 100-year flood was developed from the Flood Hazard Boundary Map for Ravenel (Reference 11), and Charleston County (Reference 7). The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map (Exhibit 3). Small areas within the flood boundaries may lie above the flood elevations, and therefore, may not be subject to flooding. Owing to limitations of the map scale and/or lack of detailed topographic data, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain

development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of the FIA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. Tidal influences were neglected when computing the floodways for Middle Branch. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 3).

As shown on the Flood Boundary and Floodway Map (Exhibit 3), the floodway widths were determined at cross sections; the boundaries were interpolated between cross sections. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Middle Branch								
A	0	100	441	3.4	8.0	4.0[2]	4.5	0.5
B	210	100	564	2.7	8.0	5.0[2]	5.7	0.7
C	2,050	157	686	2.2	8.0	6.0[2]	6.8	0.8
D	5,950	215	960	1.4	8.0	6.9[2]	7.8	0.9
E	8,450	168	783	1.7	8.3	8.3	9.3	1.0
F	12,750	271	1385	1.0	12.6	12.6	13.6	1.0
G	15,700	442	1695	0.8	13.7	13.7	14.7	1.0
H	15,990	682	3278	0.3	14.9	14.9	15.9	1.0
I	17,690	237	1062	1.0	15.1	15.1	16.1	1.0
J	20,090	199	759	1.3	17.1	17.1	18.1	1.0
K	21,990	161	532	1.9	20.6	20.6	21.6	1.0
L	24,290	90	445	2.2	26.9	26.9	27.9	1.0
M	24,410	283	1940	0.5	30.4	30.4	31.4	1.0
N	25,570	186	1136	0.8	30.6	30.6	31.6	1.0
O	28,270	596	2180	0.4	31.2	31.2	32.2	1.0
P	30,870	351	969	0.9	34.0	34.0	35.0	1.0
Q	33,470	271	695	1.0	37.5	37.5	38.5	1.0

[1]Feet upstream of Corporate Limits
[2]Water-surface elevation determined without considering backwater effects from Atlantic Ocean.

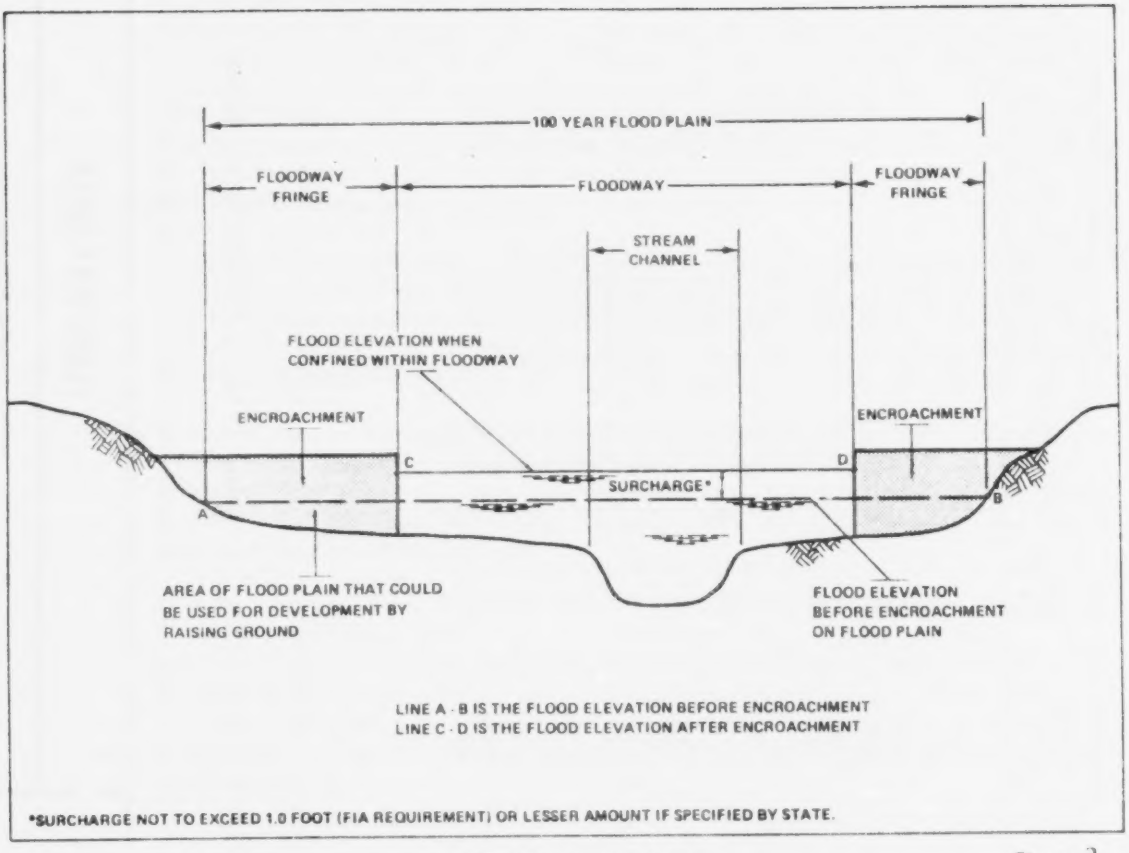
TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF RAVENEL, SC
(CHARLESTON CO.)

FLOODWAY DATA

MIDDLE BRANCH


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FIA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FLOODWAY SCHEMATIC

Figure 2

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each significant flooding source affecting the Town of Ravenel.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot

One reach meeting the above criteria was required for the flooding source of Ravenel. The location of the reach is shown on the Flood Profiles (Exhibit 1).

5.2 Flood Hazard Factors (FHFs)

The Flood Hazard Factor is used to correlate flood information with insurance rate tables. Correlations between property damages from floods and their assigned FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest one-half foot, and shown as a three-digit code. For example, if the difference between the water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, the accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the Town of Ravenel was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations.

Zone A:	Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations shown or FHFs determined.
Zones A2, A13:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHFs.

Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; or areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 4, "Flood Insurance Zone Data," summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevation for each flooding source studied in detail in the community.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the Town of Ravenel is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by the FIA.

6.0 OTHER STUDIES

In 1971, a Flood Insurance Study for the unincorporated parts of Charleston County was completed (Reference 8). The county study included a detailed analysis of the lower portion of Middle Branch. Since the completion of the county study, the Town of Ravenel has incorporated areas which were included in the study. The results of this study are compatible with those of the Charleston County Study.

No other known studies have been performed on Middle Branch in the Town of Ravenel.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the Insurance and Mitigation Division, Federal Emergency Management Agency, 1375 Peachtree Street, N.E., Suite 778, Atlanta, Georgia 30309.

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Middle Branch Reach 1	0005	-1.07	-0.34	+0.74	010	A2	Varies
Atlantic Ocean (Backwater flooding along Middle Branch and Tributary to Wallace River)	0005	-6.50	-2.70	+3.70	065	A13	Varies

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT-SEE MAP

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF RAVENEL, SC
(CHARLESTON CO.)

FLOOD INSURANCE ZONE DATA

MIDDLE BRANCH-ATLANTIC OCEAN

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Bureau of Census, U.S. Census of Population 1970.

2. Conversation with Mr. Cochran, Town of Ravenel Police Officer, July 1979.

3. U.S. Geological Survey, Water Resources Division, Columbia, South Carolina, Estimating the Magnitude of Peak Discharges for Selected Flood Frequencies on Small Streams in South Carolina, Benjamin H. Whetstone, September 1975.

4. U.S. Department of the Interior, Geological Survey, Preliminary Flood-Frequency Relations for Urban Streams, Metropolitan Atlanta, Georgia, H. G. Golden, August 1977.

5. U.S. Department of Agriculture, Soil Conservation Service, Engineering Division, Technical Release No. 55 - Urban Hydrology for Small Watersheds, January 1975.

6. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Technical Report NWS-16-Storm Tide Frequencies on the South Carolina Coast, Vance Myers, June 1975.

7. U.S. Department of Housing and Urban Development, Flood Insurance Administration, Flood Hazard Boundary and Flood Insurance Rate Maps H & I 14, 19, 20, and 24, Charleston County, S.C., November 12, 1976.

8. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, Charleston County, S.C., March 1971 and March 1973.

9. U.S. Department of Interior, Geological Survey, 7.5-Minute Series (Topographic) Maps, Scale: 1:24,000, Contour Interval 5 Feet: Ravenel, S.C.; 15-Minute Series (Topographic) Maps, Scale 1:62,500, Contour Interval 20 feet: Cottageville, S. C. (1948).

10. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Computer Program 723-X6-L202A HEC-2 Water-Surface Profiles, Davis, California, December 1968 with updates.

11. U.S. Department of Housing and Urban Development, Flood Insurance Administration, Flood Hazard Boundary Map H-01-02 Town of Ravenel, S. C., June 14, 1974.

Chow, Ven T., Open-Channel Hydraulics, McGraw-Hill Book Company, 1959.

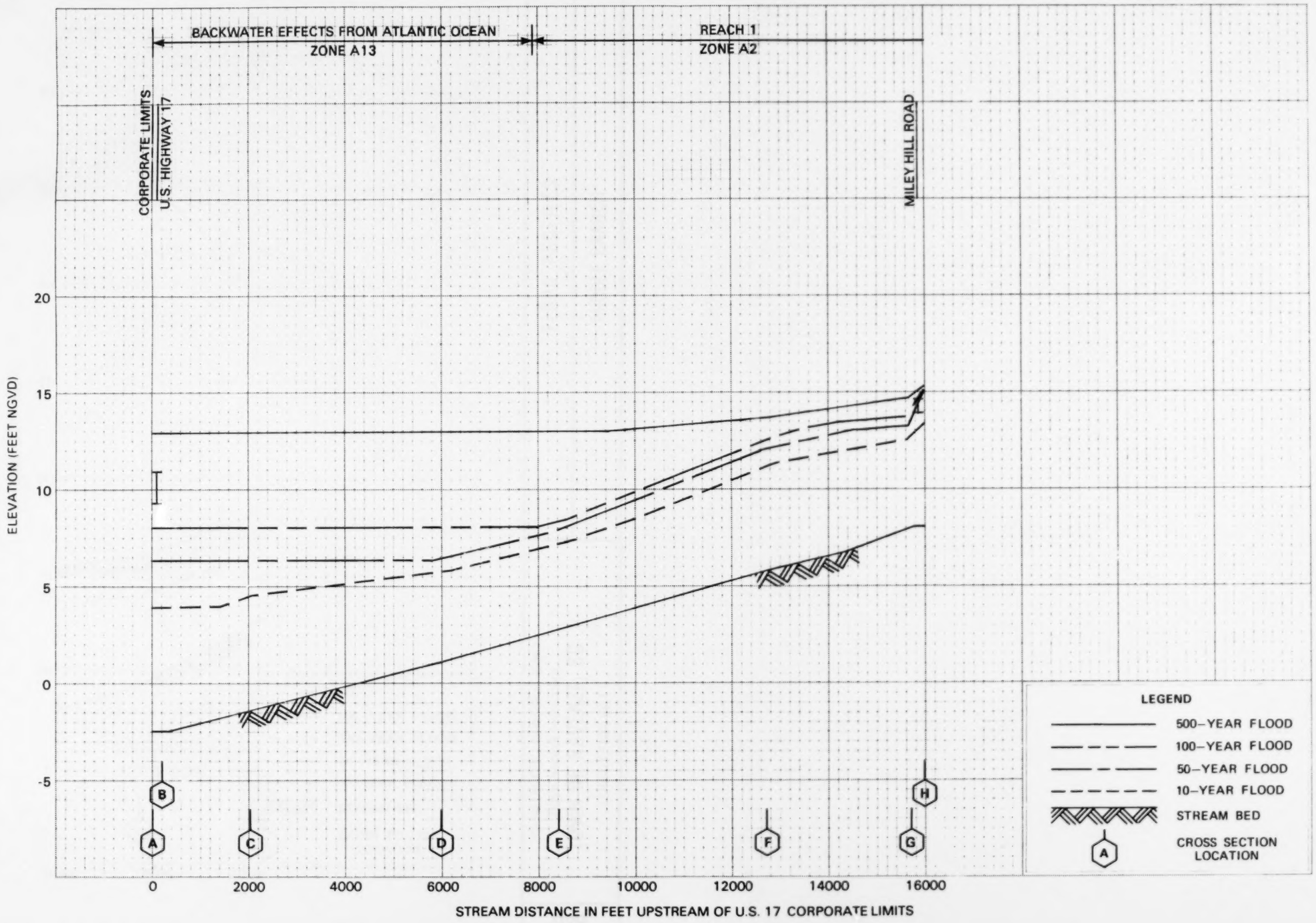
King, H. W. and Barter, E. F., Kings Handbook of Hydraulics, 5th Edition, McGraw-Hill Book Company, 1976.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, Application of the HEC-2 Bridge Routines, June 1974.

U.S. Army Corps of Engineers, Hydrologic Engineering Center, Floodway Determination Using Computer Program HEC-2, May 1974.

U.S. Department of Interior, Bureau of Reclamation, Design of Small Dams, 1974.

U.S. Department of Transportation, Federal Highway Administration, Hydraulics of Bridge Waterways, 1970.



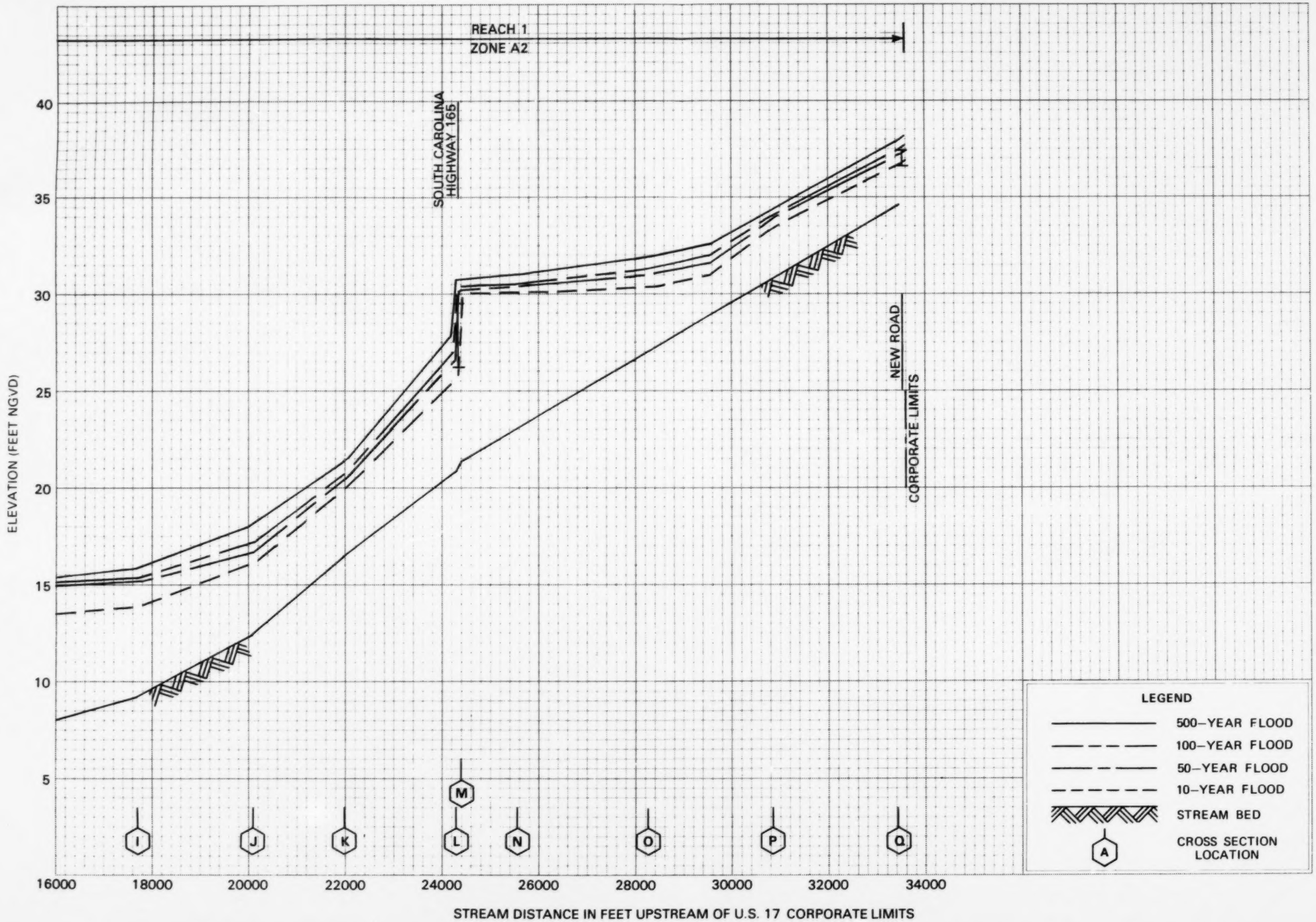
FLOOD PROFILES

MIDDLE BRANCH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF RAVENEL, SC
(CHARLESTON CO.)

01P



FLOOD PROFILES

MIDDLE BRANCH

FEDERAL EMERGENCY MANAGEMENT AGENCY
Feuleral Insurance Administration

TOWN OF RAVENEL, SC
(CHARLESTON CO.)

02P